

V-SHAPED DISC SCREEN AND METHOD OF CLASSIFYING MIXED RECYCLABLE MATERIALS INTO FOUR STREAMS

CROSS-REFERENCE TO RELATED APPLICATION

[01] This application is a continuation-in-part of co-pending U.S. application Serial No. 09/882,667 filed June 15, 2002 entitled "Disc Screen Apparatus with Air Manifold", the entire disclosure of which is hereby incorporated by reference.

FIELD OF THE INVENTION

[02] The present invention relates to machines for processing mixed recyclable materials, and more particularly, to disc screen apparatus suited for separating paper from a stream of mixed recyclable materials.

BACKGROUND OF THE INVENTION

[03] Material recycling has become an important industry in recent years due to decreasing landfill capacity, environmental concerns and dwindling natural resources. Many industries and communities have adopted voluntary and mandatory recycling programs for reusable materials. Solid waste and trash that is collected from homes, apartments or companies often combine several recyclable materials into one container. When brought to a processing center, the recyclable materials are frequently mixed together in a heterogenous mass of material. These mixed recyclable materials include newspaper, magazines, mixed paper, cardboard, aluminum cans, plastic bottles, glass bottles and other materials that may be recycled.

[04] Disc apparatus or "disc screens" are increasingly used to separate streams of mixed recyclable materials into respective streams or collections of similar materials. This process is referred to as "classifying", and the results are called "classification". A disc screen typically includes a frame in which a plurality of rotatable shafts are mounted in parallel relationship. A plurality of discs are

mounted on each shaft and a chain drive commonly rotates the shafts in the same direction. The discs on one shaft interleave with the discs on each adjacent shaft to form screen openings between the peripheral edges of the discs. The size of the openings determines the dimension (and thus the type) of material that will fall through the screen. Rotation of the discs, which have an irregular outer contour, agitates the mixed recyclable materials to enhance classification. The rotating discs propel the larger articles which are too big to fall between the discs across the screen. The general flow direction extends from an input area where the stream of material pours onto the disc screen to an output where the larger articles pour off of the disc screen. The smaller articles fall between the discs onto another disc screen or a conveyor, or into a collection bin.

[05] There is a substantial market for recycled newspaper. Therefore, it is important that any disc screen which is designed to classify mixed recyclable materials be capable of thoroughly separating newspaper from the heterogenous mass of material. Prior disc screen apparatus designed to handle a stream of mixed recyclable materials have included multiple overlapping disc screens with different angles of inclination and different sizes of openings between the discs. They are capable of separating broken glass from containers. They are also capable of separating mixed paper and newspaper from the stream of mixed recyclable materials. These apparatus can be tilted at various angles to improve the efficiency of separation. However, a consistent problem that has been encountered with disc screen apparatus that is used to classify mixed recyclable materials is the fact that newspaper sometimes rolls into a clump or mass midway up the final disc screen and will not be ejected off of the upper terminal end thereof. If the angle of inclination of the final disc screen is reduced, then containers and bottles will be undesirably conveyed up the final disc screen and off of its discharge end. This problem is exacerbated where the newspaper is wet or damp.

[06] Most disc screen apparatus that have been developed for classifying mixed recyclable materials have used a flat, generally planar disc screen. The stream of mixed recyclable material is conventionally deposited toward the lower end of the screen along a conveying direction which is generally perpendicular to that of the shafts. The screen is typically inclined and much of the material swirls at the location of deposit. Paper tries to move upwardly as containers try to roll rearwardly

and this conflict in flow directions inherently limits the throughput of the screening apparatus. The efficiency of the classification process is also significantly impeded by this conflict in flow directions.

Furthermore, it has sometimes been necessary to install multiple blowers along the relatively wide lower end of the disc screen in order to prevent paper from falling off the same.

SUMMARY OF THE INVENTION

[07] In accordance with the present invention a disc screen apparatus has a V-shaped configuration with a lowermost region that provides a laterally inclined trough that receives the mixed recyclable materials. Broken glass falls downwardly between the discs of the lowermost region. Large articles, such as plastic milk bottles and soda pop containers, tumble down the trough and eventually fall off its lower end. Newspaper is conveyed upwardly over the terminal upper ends of a pair of vertically inclined regions of the disc screen apparatus. In the preferred embodiment, the frame of the disc screen apparatus incorporates ducting for connecting a source of pressurized air to one or more air manifolds that blow air toward the vertically inclined regions of the disc screen apparatus for helping the discs in these regions convey newspaper up the inclined regions and over their upper ends. The angle of inclination of the vertically inclined regions is preferably adjustable with a lifting mechanism in order to optimize the efficiency of classification of the V-shaped disc screen apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

[08] Fig. 1 is a diagrammatic side elevation view of a first embodiment of the present invention.

[09] Fig. 2 is a fragmentary top plan elevation view of the first embodiment embodiment.

[10] Figs. 3 and 4 illustrate a preferred structure for rotatably mounting and driving the shafts of the first embodiment that carry the discs that classify the mixed recyclable materials.

[11] Fig. 5 is an elevation view of an infed end of a second embodiment of the present invention.

[12] Fig. 6 is a side elevation view of the second embodiment.

[13] Fig. 7 is an elevation view of an outfeed end of the second embodiment.

[14] Fig. 8 is a top plan view of the second embodiment

[15] Fig. 9A is a top plan view of a third embodiment of the present invention that incorporates air ducting in its frame that feeds a plurality of air manifolds.

[16] Fig. 9B is a longitudinal sectional view of the third embodiment taken along line 9B-9B of Fig. 9A.

[17] Fig. 9C is a cross-sectional view of the third embodiment taken along line 9C-9C of Fig. 9A.

[18] Fig. 10 is a diagrammatic side elevation view of a V-shaped disc screen with articulating inclined sections representing a fourth embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[19] Referring to Fig. 1, a first embodiment of the present invention comprises a recycling apparatus 110 in the form of a trough-shaped disc screen 112 equipped with a pair of separate air manifolds 114 and 116. Referring to Fig. 2, the recycling apparatus 110 includes a frame 118 that rotatably supports a plurality of laterally extending shafts 22 that spin about laterally extending axes such as 120. The shafts 22 of the trough-shaped disc screen 112 are longitudinally spaced and are located at progressive heights to provide a generally V-shaped configuration as best seen in Fig. 1. The shaft that rotates about the axis 120 (Fig. 2) and the additional shafts to the left of axis 120 are rotated by a motor 122 through a drive linkage 124 in a counter-clockwise direction in Fig. 1. The shafts to the right of the axis 120 (Fig. 2) are rotated by another motor 126 (Fig. 1) via a drive linkage 128 to rotate the discs 30 on these shafts in a clockwise direction in Fig. 1. The drive linkages 124

and 128 preferably each include a plurality of sprockets as described hereafter which are mounted to the ends of the shafts 22 and a plurality of separate chains (not illustrated) entrained about these sprockets. Sprockets (not illustrated) are also mounted on separate gear reduction assemblies (not illustrated) driven by each of the motors 122 and 126. The shafts 22 could be driven directly or indirectly with gears, belts, chain drives, transmissions, electric motors, hydraulic motors, internal combustion engines, and various combinations of these drive means.

[20] A stream of mixed recyclable materials is carried by a conveyor 130 (Fig. 1) and deposited onto a lowermost region 131 of the trough-shaped disc screen 112. While the discs 30 are referred to as "discs" they preferably have an irregular outer contour or shape so that when all of the shafts 22 of the recycling apparatus 110 are rotated, mixed recyclable materials deposited thereon will be agitated and moved along in various conveying directions. In accordance with well know techniques, the spacing of the discs 30 and the resulting dimensions of the openings therebetween determines the size of the materials that will fall downwardly between the discs 30.

[21] The shafts of the lowermost region 131 are preferably slightly downwardly angled from the horizontal, at an angle, for example, of about five degrees. The spacing of the discs 30 along the various shafts of the trough-shaped disc screen 112 and the angle of vertical inclination of the two vertically inclined regions 112a and 112b of the disc screen 112, along with the rotational speed of these discs, is selected to optimumly classify the stream of mixed recyclable materials infed from the conveyor 130.

[22] Optimum classification by the recycling apparatus 110 is enhanced by the air manifolds 114 and 116 which are connected to squirrel cage blowers 132 and 134 (Fig. 2). The manifolds 114 and 116 may be formed of segments of plastic or metal pipe with holes bored therein at intervals to form nozzles that eject streams of air toward the discs 30 to press newspaper against the discs and aid in the discs 30 conveying the same upwardly. Preferably the streams of air are inclined to help advance the newspaper upwardly. Each of the air manifolds 114 and 116 includes a plurality of laterally extending and longitudinally spaced conduits each having a plurality of laterally spaced nozzles. The

conduits are coupled to a longitudinally extending header, the headers being connected to respective ones of the blowers 132 and 134. These conduits are positioned sufficiently close to the first and second vertically inclined regions 112a and 112b so that containers that are partially conveyed upwardly along the first and second vertically inclined regions 112a and 112b can tumble over the first and second air manifolds 114 and 116. Other sources of pressurized air besides the squirrel cage blowers 132 and 134 may be utilized, such as fans, pumps, pressurized tanks, and so forth.

[23] The lateral spacing between the discs 30 of the lowermost region 131 is less than the lateral spacing between the discs 30 of the vertically inclined regions 112a and 112b. Broken glass falls downwardly between the discs 30 of the lowermost region 131 of the trough-shaped disc screen 112. Mixed recyclable materials fall through the discs 30 located along the intermediate portions of the vertically inclined regions 112a and 112b. Newspaper is conveyed upwardly over the output ends at the upper terminal ends of the vertically inclined regions 112a and 112b. Large articles such as plastic milk bottles and soda pop containers tumble down the vertically inclined regions 112a and 112b of the V-shaped disc screen 112 and eventually fall off of the side of the recycling apparatus 110. Preferably the axes of the shafts 22 of the inclined region 112a all extend in a first common plane and the axes of the shafts of the inclined region 112b all extend in a second common plane.

[24] Thus a stream of mixed recyclable materials is conveyed onto one side of the V-shaped disc screen 112 by the conveyor 130 at the end marked "INFEED" in Fig. 1 and large articles are conveyed out the other side of the V-shaped disc screen 112 at the side marked "CONTAINERS OUT" in Fig. 1.

[25] Persons skilled in the art of designing recycling apparatuses will be well familiar with the various mechanical details necessary to construct the recycling apparatus 110 as well as the individual discs 30 and the bearing assemblies that support the square shafts 22. Such additional details may be found in my U.S. Patent No. 6,318,560 granted November 20, 2001, the entire disclosure of which is specifically incorporated herein by reference.

[26] Figs. 3 and 4 illustrate a preferred structure for rotatably mounting and driving the shafts 22 of the recycling apparatus 110. Each shaft 22 is preferably a hollow steel beam having a square cross-section. The square shape of the shaft 22 facilitates cutting off of twine, rope, plastic wrap, etc. that becomes tightly wrapped around the shafts 22 during the classification process. This wound material may be manually cut off the shaft 22 with a box cutter or other sharp knife. The use of square shafts 22 as the supporting axles for the discs 30 also allows them to be clamped around the shafts, or slid over the same, to achieve a positive driving engagement between the shafts 22 and the discs 30. Each of the discs 30 has a square aperture therethrough which receives its corresponding shaft 22. A molded polyurethane plug 142 (Fig. 3) having a square outer shape is inserted into the end of the shaft 22. Preferably the internal dimensions of the square interior of the shaft 22 and the outer dimensions of the plug 142 are selected to provide a tight fit. The plug 142 has a square shoulder 142a which limits the depth of its insertion into the shaft 22. A steel stub shaft 144 has a hexagonal shaped inner end 144a that fits snugly within a hexagonal interior opening in the plug 142. A cylindrical collar 146 (Fig. 4) fits over the outer portion of the hexagonal inner end 144a. A round outer end 144b of the stub shaft 144 is journaled in a pair of bearing assemblies 148 and 150 supported on a beam 152 and a U-shaped frame member 154. A pair of sprockets 156 and 158 are keyed to the round outer end 144b of the stub shaft 144 and have respective drive chains (not illustrated) entrained about the same. The use of the polyurethane plug 142 avoids any necessity of welding or otherwise securing the stub shaft 144, a collar or some other metal interface directly to the shaft 22. The plug 142 also aligns the rotational axis of the cylindrical stub shaft 144 with the rotational axis of the square shaft 22 and provides some beneficial shock absorbing characteristics.

[27] Other plastic materials besides polyurethane will suffice if they have sufficient strength and durability, such as DELRIN® plastic. The plug should be made of a resilient deformable material to allow a squeeze fit into the interior of the shaft 22.

[28] Those skilled in the art of designing apparatus for classifying a stream of mixed recyclable materials will appreciate that the disc spacings, angles of inclination, and rotational speeds of the recycling apparatus 110 are selected to ensure that the rotating discs 30 will optimally classify and

sort the input stream of mixed recyclable materials into three separate streams in order to achieve the highest percentage or degree of homogeneity of the portions.

[29] Figs. 5-8 illustrate a second embodiment of the present invention in the form of a V-shaped disc screen apparatus 170 including a V-shaped frame 172 made of welded hollow steel box beams. The apparatus 170 has a plurality of square shafts 174 whose ends are rotatably supported in the opposite sides of the frame 172. The shafts 174 are parallel and spaced apart and carry discs 176a and 176b that are interleaved between adjacent shafts 174. The shafts 174 and the discs 176a and 176b are divided into vertically inclined regions 180 and 182 on either side of a center line 178 of the frame 172. The frame 172 is supported on a base 184 that can be inclined in its own configuration, or variably inclined by lifting means (not shown) such as a jack screw or hydraulic cylinder so that a lowermost region of the interleaved discs 176a that form a trough 186 is slightly inclined moving from left to right in Fig. 6.

[30] A stream of mixed recyclable materials is feed onto the trough 186 in a direction that is substantially parallel to the direction in which the shafts 174 extend. The stream of mixed recyclable materials is fed through an inlet opening 188 (Fig. 5) in one side wall of the frame 172 and onto the discs 176a of the trough 186. The mixed recyclable materials are agitated by the irregularly shaped discs 176a and broken glass, along with any other small refuse, falls through the discs 176a of the trough 186 and through the base 184 into a catch bin (not illustrated) or onto a conveyor (not illustrated). Newspaper is conveyed upwardly by the irregularly shaped discs 176b in the vertically inclined regions 180 and 182 and up and over the upper terminal ends of these regions, which are defined by the discs 176b mounted on the highest shafts 174. This newspaper falls onto separate conveyors (not illustrated). Large items such as bottles and containers migrate over the discs 176a of the trough 186 and fall off of the lower end thereof through an outlet opening 190 (Fig. 7) in the other side wall of the frame 172. These containers and other large articles drop into another bin (not illustrated) or onto another conveyor (not illustrated).

[31] As illustrated in Figs. 5 and 7, the discs 176a of the trough 186 have a different exterior contour or shape than the discs 176b of the inclined regions 180 and 182. The lateral spacing between the discs 176b of the inclined regions 180 and 182 is larger than the lateral spacing between the discs 176a of the trough 186. Certain portions of the mixed recyclable materials such as mixed paper and cardboard and other debris falls between the spaces between the discs 176b of the inclined regions 180 and 182 for collection into other bins (not illustrated) or onto other conveyors (not illustrated). If desired, the V-shaped disc screen apparatus 170 can be equipped with air manifolds for pressing the newspaper against the discs 176b of the vertically inclined regions 180 and 182. Also, a fan can be positioned to blow air through the outfeed opening 190 (Fig. 7) to prevent newspaper from falling through this opening. Only a single fan or blower need be utilized instead of the multiple fans and blowers required at the lower end of inclined flat disc screens that have a relatively wide lower end.

[32] A major advantage of my V-shaped disc screening apparatus over conventional planar screens that have been used to classify mixed recyclable materials is that the former can achieve high rates of separation with substantially fewer discs. This means that the V-shaped disc screen apparatus can take up much less space than the typical arrangement of multiple, overlapping planar screens. Since the containers are already deposited at the trough of the V-shaped disc screen apparatus they do not roll downwardly in a manner that impedes upward movement of newspaper.

[33] Figs. 9A, 9B and 9C illustrate a third embodiment of the present invention in the form of a disc screen apparatus 200 having a frame 201 made of hollow welded steel box beams. A blower 202 is coupled to a rear laterally extending box beam 204a so that pressurized air is conveyed through longitudinally extending box beams 204b and 204c that form opposite sides of the disc screen apparatus 200. A plurality of longitudinally spaced air manifolds 206 extend laterally across a plurality of discs 208 for blowing air downwardly toward the discs 208 as indicated by the arrows in Figs. 9B and 9C. This helps convey a paper portion of a stream of mixed recyclable materials upwardly (left to right in Figs. 9A and 9B) along and on top of the discs 208. The normal inclination of the disc screen apparatus 200 is not illustrated in Fig. 9B. The opposite ends of the air manifolds 206 are coupled to respective ones of the box beams 204b and 204c for receiving pressurized air

therefrom. The air manifolds 206 preferably have a construction similar to those already described in conjunction with the recycling apparatus 110 of Figs. 1 and 2. Thus the disc screen apparatus 200 advantageously has ducting within the frame 201 for connecting the source of pressurized air in the form of the output duct of the blower 202 to the air manifolds 206. In the preferred embodiment this ducting is provided in the form of hollow box beams 204a, 204b and 204c. The axes of the shafts 210 that carry the discs 208 extend in a common plane in the disc screen apparatus 200, but it will be understood that the shafts could have other arrangements, such as the V-screen arrangement illustrated in Fig. 1, for example.

[34] Fig. 10 illustrates a fourth embodiment of the present invention in the form of a disc screen apparatus 220 having a V-shaped configuration. It is similar to the V-shaped disc screen apparatus 170 of Figs. 5 - 8, except that its inclined sections 222 and 224 are pivotally mounted to a base frame portion 226 via pivot assemblies 228 and 230. In the fourth embodiment the pivot assemblies comprise selected ones of the shafts that support the discs. Lifting means in the form of hydraulic cylinders 232 and 234 are provided for independently varying the angle of inclination of the inclined sections 222 and 224 to adjust and optimize the separation of mixed recyclable materials. The lifting means 232 and 234 can be any other conventional lifting devices such as motorized jack screws, pneumatic lifters, and equivalent mechanical mechanisms used in heavy machinery to lift and move large frame members. The articulating V-shaped disc screen apparatus 220 also incorporates internal air ducting 236 and 238, which feed air manifolds 240, similar to those of the disc screen apparatus 200 illustrated in Figs. 9A, 9B and 9C.

[35] While I have described several embodiments of a recycling apparatus in accordance with the present invention, variations and modifications thereof will occur to those skilled in the art. Therefore, the protection afforded my invention should only be limited in accordance with the following claims.

WHAT IS CLAIMED IS: